(12) UK Patent Application (19) GB (11) 2 238 680 (13) A

(43) Date of A publication 05.06.1991

(21) Application No 8927217.3

(22) Date of filing 01.12.1989

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(51) INT CL[5]
H03G 3/32

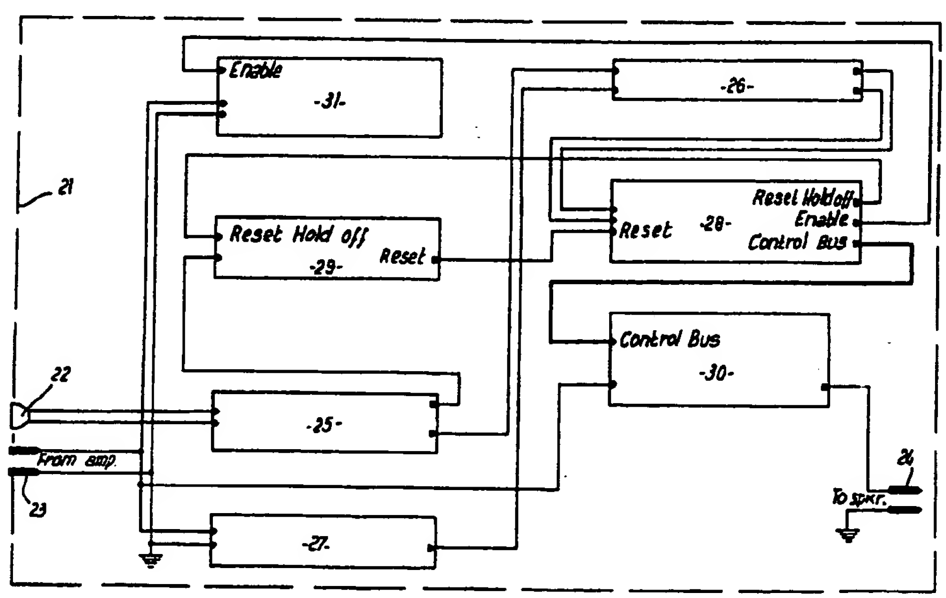
(52) UK CL (Edition K)
H3G GSE G10S G11E G8
U1S S2116

(56) Documents cited
GB 2214013 A GB 1518574 A

(58) Field of search
UK CL (Edition K) H3G GSE
INT CL[5] H03G 3/24 3/32

(54) Sound level control equipment

(57) Automatic level control equipment, for example for a coin-operated music system, has a sound level adjusting device, such as a variable resistance device (30) interposed between amplifier inputs (23) and outputs (24) for sound reproducing apparatus, such as loudspeakers. The resistance (30) is adjusted by control circuitry (28) to compensate for changes in the level of background noise picked up by a microphone (22). The control circuitry (28) has microphone monitoring filters (25) and amplifier output monitoring filters (27) operable at different frequency bands so that background noise can be monitored at different frequency bands, depending on the frequency distribution of the sound output of the amplifier. If the amplifier has a sound output in the same frequency band as that being monitored in the background noise, the circuitry can switch to a different monitored frequency band of background noise.



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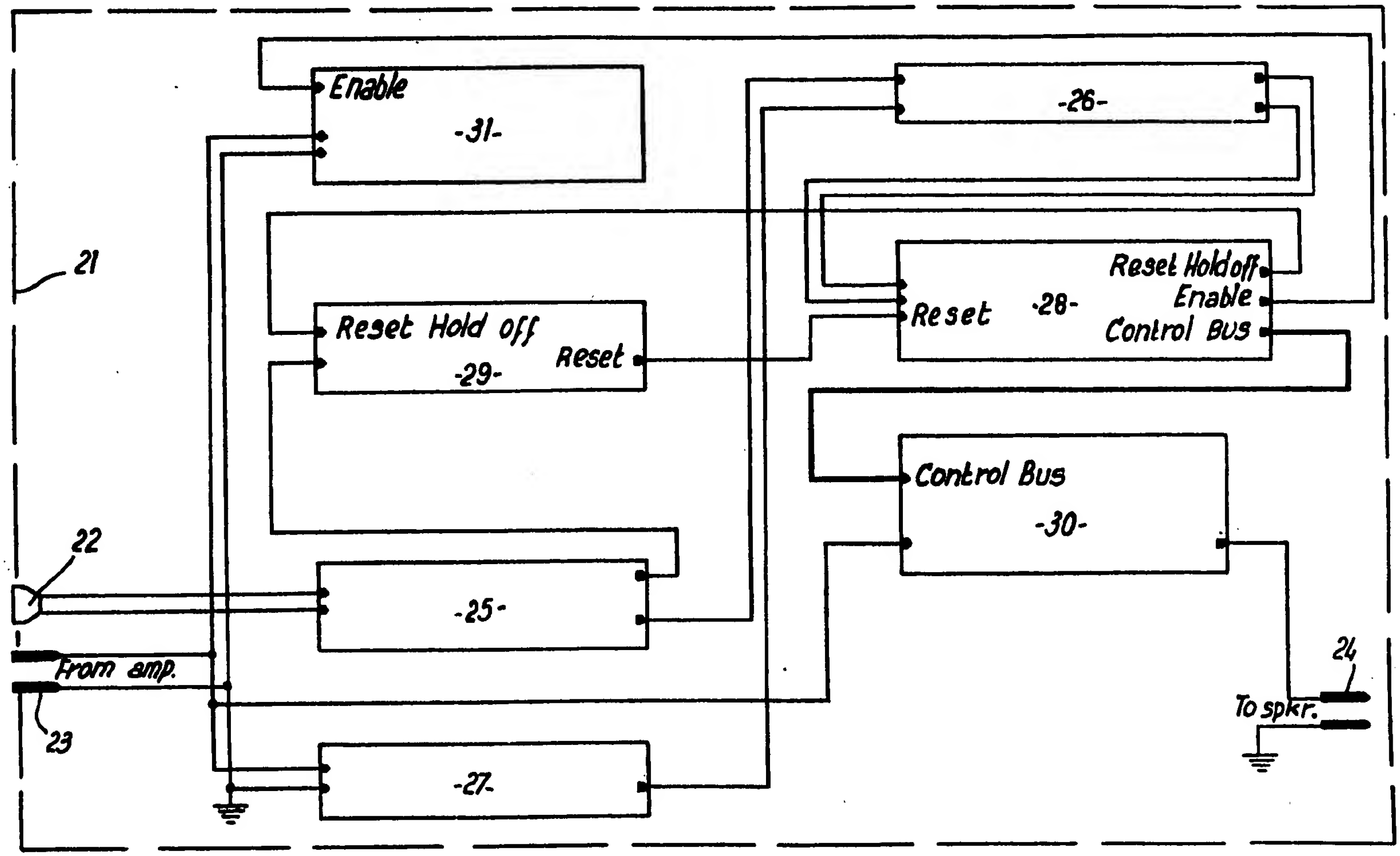

Enable
-31-
Reset Hold off
Reset
-29-
-25-
-27-
-26-
Reset Holdoff
Enable
Control Bus
Reset
-28-
Control Bus
-30-
21
22
From amp.
23
24
To spkr.

2238680

SOUND LEVEL CONTROL EQUIPMENT

This invention relates to automatic sound level control equipment.

Coin-operated music playing machines (juke boxes) are commonly provided at sites, such as public bars and like establishments, where the amplitude of background noise can vary widely throughout a period of time. Thus the noise amplitude may be low at the start of an evening when there are few people present; the amplitude may rise to a much higher level later in the evening when there are many people present engaged in conversation; and there may be occasional large increases in amplitude for example when a group of people are laughing or celebrating loudly.

It is important to be able to adjust the music volume in correspondence with the changes in background noise so that the volume is not uncomfortably loud during relatively quiet periods but is loud enough to be heard during noisy periods. If this adjustment is not made, the juke box wil tend not to be used so frequently, and the earnings of the machine will correspondingly fall.

The usual practice is for the volume to be adjusted as required with one or more manual controls. Commonly in a bar where there are multiple loudspeakers connected to a remote amplifier (e.g. in a cellar) there are variable resistors interposed respectively in series with the loudspeakers and these are located behind a bar counter where they can be operated by a person serving behind the counter. With this arrangement there is the problem that the person responsible for operating the volume controls may forget or may be too busy to do so, whereby there may be periods, possibly of appreciable duration,

during which the music volume is at an inappropriate level.

In our copending application No. 8900754.6 there is described automatic level control equipment for use with a sound system having sound reproducing apparatus driven by an amplifier, said equipment comprising:

a device interposable between the amplifier and the sound reproducing apparatus, the device being adjustable to change a characteristic of the output fed from the amplifier to the apparatus and hence the level of the sound produced thereby;

a sound sensor for sensing sound in the environment of the sound reproducing apparatus; and

a control circuit connected to the sensor and to the adjustment device to effect said adjustment of the device in correspondence with a selected parameter of the said environment sound, said control circuit including a filter device arranged to be responsive to a frequency or band of frequencies of sound produced by said sound system so as to modify said adjustment of said device in correspondence therewith.

With this arrangement automatic adjustment of the sound level can be achieved in a simple, convenient and reliable manner.

Due to the provision of the filter device it is possible to reduce or eliminate pick-up by the sound sensor of a monitored frequency derived from the sound system rather then from background noise, without unduly adversely affecting the quality of the sound from the sound system. In particular, as described in accordance with a preferred embodiment, the filter device is responsive to a frequency or band of frequencies the same or similar to a frequency or band of frequencies

hence the level of the sound produced thereby;

a sound sensor for sensing sound in the environment of the sound reproducing apparatus; and

a control circuit connected to the sensor, the adjustment device and the output from the amplifier, said control circuit incorporating multiple sensor filters corresponding to different respective frequency bands of environment sound and being arranged to effect said adjustment of the device in correspondence with the level of said environment sound within at least one selected said frequency band; said control circuit further incorporating at least one output filter corresponding to a frequency band of amplifier output sound whereby said selection of the (or each) said frequency band of environment sound is determined in dependence on the level of said output sound within the respective frequency band.

With this arrangement it is possible to monitor environment sound at different frequency bands in correspondence with monitoring of a frequency band in the amplifier output whereby, for example, whenever the amplifier output has a content of the same frequency band as that being monitored in the environment sound, the circuit can operate to switch to a different monitored frequency band of the environment sound. In this way interrupted monitoring can be avoided or minimised.

The arrangement may be such that only one frequency band of the amplifier output is monitored, corresponding to one of the frequency bands for the monitoring of the environment sound. Preferably however, there are multiple amplifier output filters whereby monitoring of multiple frequency bands of the amplifier output corresponding respectively to

the multiple frequency bands of the environment sound can be achieved.

Instead of using different discrete filter devices (or pairs of filter devices) with appropriate control circuitry operable to switch the frequency band as required thereby giving the affect of multiple filters.

With regard to the adjustment device this may comprise a device of variable resistance. The variation may be effected by changing the resistance of a component in analogue manner. Alternatively the variation may be effected digitally by switching of arrangements of resistive components.

The sensor may comprise a microphone of any suitable kind.

The control circuit may be at least partially of a digital nature and may incorporate a microprocessor.

The level of the sound may comprise the volume or power content thereof. With regard to the frequency bands, these may be narrow bands located between say 500 or 600 Hz. The bands are preferably non-overlapping and not liable to occur chromatically.

As appropriate the sensor filters may be arranged to be switched on or off (or to be attenuated). Thus the control circuit may be arranged to operate a switch device interposed in line with the filters or to switch controllable filters or to take any other suitable control action.

The frequency band of the or each amplfier output filter may be the same as that of the corresponding sensor filter. Alternatively, the output filter may operate over a band (say 490 to 510 Hz) while the sensor filter device operates essentially at a spot frequency (say 500 Hz). Preferably the two filters have the same central frequency although other arrangements e.g. involving overlapping bands may be used.

It may be desirable to ensure that the control circuit does not 'over-react' such that the volume is continually increased in response to peaks in the background noise. Thus, the control circuit is preferably arranged to respond to a lowest level of background noise during a predetermined monitoring period (of say two to three minutes).

The control equipment may be arranged to be operational continuously whilst the amplifier is producing an output to drive the sound reproducing apparatus and during this continuous period of operation the background noise may be sampled, and the adjustment device consequently adjusted as required, on a continuous or intermittent basis as desired. Preferably, the adjustment of the device controlling sound level is effected at intervals of sufficient duration to ensure that the adjustment does not become inconvenient or irritating. Thus, the background noise may be monitored over a short but appreciable period of time (say two or three minutes) before the need for adjustment is assessed.

The aforesaid continuous operation of the control equipment may be triggered by the output of the amplifier.

When the amplifier is inactive the control equipment may be activated at intervals (say every 10 minutes) to sample the background noise for a short period of time (say for 30 seconds), the control equipment being deactivated if there is no amplifier output at the end of this sampling period. In this way it can be achieved that the sound is already set to an appropriate level when the amplifier is first activated.

The control equipment preferably incorporates a battery for powering the control circuit and this may be a rechargeable battery

which is charged in use from the audio output of the amplifier. In this way it is possible to construct the equipment as a separate unit which is essentially maintenance-free and which can be readily fitted into an existing sound system with little disruption of such system. In particular it will be appreciated that it need only be necessary to interpose the unit between the amplifier and the sound reproducing apparatus; no modification of the amplifier need be required.

The control equipment may be used in a bar or other premises to control the sound level of a coin-operated music system. It is however to be understood that the invention is not intended to be restricted to this field of application and the equipment may be used in any suitable context for any suitable purpose.

It will also be understood that in the case of a sound system having multiple loudspeakers or other sound reproducing apparatus connected to the same or different amplifiers, there may be a respective said control equipment for each sound reproducing apparatus so that independent sound level control at different locations can be achieved. Also it will be understood that provision may be made for manually overriding or modifying the effect of the control equipment as desired.

The invention will now be described further by way of example only and with reference to the accompanying drawing which is a block circuit diagram of one form of control equipment according to the invention.

The embodiment illustrated comprises a housed unit 21 with a microphone 22, and input and output terminals 23, 24 respectively for connection to an amplifier and to a loudspeaker.

The microphone is connected via a preamplifier stage 25 to a filter and detection stage 26. Also, the input terminals 23 are connected via a scaling stage 27 to the filter and detection stage 26 which is operational in two narrow frequency bands in the range 500-600 Hz. The output of the latter stage 26 is fed to a microprocessor-based control circuit 28 incorporating an analogue-to-digital converter. The pre-amplifier stage 25 is also connected to a re-set input of the control circuit 28 via a noise switch 29. The control circuit 28 controls an audio attenuation device 30 which is interposed between the input and output terminals 23, 24.

A power supply 31 is provided for operation of the unit 21 and this comprises a rechargeable Ni-Cd battery together with circuitry for charging the battery from audio signals at the input terminals 23.

The operation of the unit is as follows:

After installation, the unit 21 is permanently powered. Back up power during a standby or idle state (i.e. when there is no audio signal at the input terminals 23) is derived from the battery in the power supply 31. Only the microprocessor-based control circuit 28 (PIC-processor) in a 'sleeping' mode, and the noise-switch 29 with associated circuitry (forming part of the pre-amplifier stage 25) are powered and they have a very low level of consumption.

In this mode, the pre-amplifier stage 25 is configured to amplify over a wide frequency bandwidth and responds to any noise picked up by the microphone 22. The output of the pre-amplifier stage 25 is compared with a predetermined value. If the rate at which this value is exceeded, exceeds a predetermined rate, a re-set circuit is initiated

which 'wakes up' the PIC-processor.

Immediately the processor is awakened it does the following:
inhibit the re-set circuit;
re-configure the pre-amplifier stage 25 into a broad low-pass filter;
connect power supply to the entire unit;
commence main operation.

Approximately every second, simultaneous reading of ambient noise (at a first narrow frequency band centred on 510 Hz) and detection of any component of the same frequency band in the audio signal at the input terminals 23 is carried out.

Assuming that no 510 Hz component is present in the audio signal, a figure for the average ambient noise level is calculated. At approximately 30 second intervals the attenuation level is calculated using the average ambient noise figure. If an alteration of attenuation is indicated, this is effected.

The ambient noise level is measured by filtering the signal after pre-amplification using a very narrow 3Hz bandwidth filter. The filtered signal is then rectified and smoothed before passing it to the analogue-to-digital converter and the control circuit 28. The control circuit 28 reads the digital value as the ambient level.

In the event that there is a 510 Hz component in the audio signal, this is measured after first scaling with the scaling amplification stage 27. The scaled component is then filtered using a 6 Hz bandwidth filter and the filtered output is rectified, smoothed converted to digital and evaluated by a comparator having a reference level pre-set by the microprocessor of the control circuit 28.

In practice, analogue-to-digital conversion is achieved using a digital-to-analogue converter with a comparator with the microprocessor controlling the output of the converter. Several attempts are made at estimating the value to be converted before the correct value is arrived at. It is therefore a straightforward matter to check the level of the 510 Hz component in the audio signal between evaluation, so achieving virtually simultaneous checking of 510 Hz component in the audio signal and 510 Hz ambient noise level picked up by the microphone 22.

If there is a 510 Hz component in the audio signal, average level of ambient noise at 510 Hz is not calculated. Instead the filter circuitry is reconfigured to permit reading of ambient noise at a different narrow frequency band within the 500-600 Hz range, and corresponding detection of any component of the same frequency band in the audio signal. If the frequency band monitored in the ambient noise is not present in the audio signal the average noise level is calculated and periodically a new attenuation level is calculated by the microprocessor and, if necessary, the attenuation device 30 is adjusted.

If the level of ambient noise at the monitored frequency has been at or near zero for a period of time, the microprocessor turns off the power supply to unnecessary parts of the circuit and the microprocessor returns to its 'sleep' mode. The attenuation device will be at its maximum level in response to the detected minimum level of ambient noise. The relative volume of audio output to ambient noise is set by adjustment of an attenuating potentiometer in the microphone pre-amplification stage 25.

During operation, the audio signal is sufficient to power the complete

circuit and also recharge the Ni-Cd battery. If there is no audio signal within a predetermined time after being 'awakened' the microprocessor sets maximum attenuation of music and resumes its 'sleep' in order to preserve battery power.

In the embodiment described two (or more) filters are provided so that the ambient noise level can be monitored in two or more separate bands centred on different frequencies within the range of say 500 to 600 Hz. The operation is such that normally ambient noise is monitored in one of the bands. In the event that the audio signal is found to have a component in the same band, the circuitry then operates so that ambient noise is monitored in the other band (or one of the other bands).

Most preferably, there are two or more 'pairs' of filters so that the frequency band at which the audio signal is monitored can change to correspond with changes in the frequency band at which the ambient noise level is monitored. Thus, the circuitry can switch from band to band as required depending on the frequency content of the audio signal. In this way it is possible to achieve effective continuous sampling.

Instead of switching from band to band it is possible to monitor all of the bands and to use an arrangement whereby on detection of a component of one band in the audio signal the corresponding filter (or pair of filters) is inhibited or disabled.

Rather than using multiple filter pairs it is possible to use a single filter pair with provision for simulating additional pairs by changing the central frequency.

Especially in the case of music control, the separate bands should have central frequencies not liable to occur chromatically.

It is of course to be understood that the invention is not intended to be restricted to the details of the above embodiment which are described by way of example only. Thus, for example, the invention is not restricted to use in the context of a music system where people-derived background noise is monitored. The invention may be used with other systems (e.g. a speech amplification system) and/or to monitor other background noise (e.g. machine noise in a factory etc.), or for use with vehicle audio systems e.g. to compensate for road noise in a motor car.

CLAIMS

1. Automatic level control equipment for use with a sound system having sound reproducing apparatus driven by an amplifier, said equipment comprising:

a device interposable between the amplifier and the sound reproducing apparatus, the device being adjustable to change a characteristic of the output fed from the amplifier to the apparatus and hence the level of the sound produced thereby;

a sound sensor for sensing sound in the environment of the sound reproducing apparatus; and

a control circuit connected to the sensor, the adjustment device and the output from the amplifier, said control circuit incorporting multiple sensor filters corresponding to different respective frequency bands of environment sound and being arranged to effect said adjustment of the device in correspondence with the level of said environment sound within at least one selected said frequency band; said control circuit further incorporating at least one output filter corresponding to a frequency band of amplifier output sound whereby said selection of the (or each) said frequency band of environment sound is determined in dependence on the level of said output sound within the respective frequency band.

2. Equipment according to claim 1 wherein there are multiple output filters for use in monitoring multiple frequency bands of the amplifier output corresponding respectively to the multiple frequency bands of the environment sound.

3. Equipment according to claim 1 or 2 wherein multiple said filters are provided by switching circuitry between different frequency bands of operation.

4. Equipment according to any one of claims 1 to 3 wherein the adjustment

device comprises a variable resistance device.

5. Equipment according to claim 4 wherein the variation of the resistance device is effected digitally by switching arrangements of resistive components.

6. Equipment according to any one of claims 1 to 5 wherein the sensor comprises a microphone.

7. Equipment according to any one of claims 1 to 6 wherein the control circuit is of a digital nature and incorporates a microprocessor.

8. Equipment according to any one of claims 1 to 7 wherein the frequency band of the (or each) amplifier output filter is the same as that of the corresponding sensor filter.

9. Equipment according to any one of claims 1 to 7 wherein the output filter operates over a band whereas the sensor filter operates essentially at a spot frequency.

10. Equipment according to any one of claims 1 to 9 wherein the control circuit is arranged to respond to a lowest level of background noise during a predetermined monitoring period.

11. Equipment according to any one of claims 1 to 10 which is operable continuously while the amplifier is producing an output to drive the sound reproducing apparatus, the background noise being sampled during this continuous period.

12. Equipment according to claim 11 wherein the continuous operation of the control equipment is triggered by the output of the amplifier.

13. Equipment according to claim 12 wherein the control equipment is deactivated if there is no amplifier output at the end of a sampling period.

14. Equipment substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

15. Equipment according to any one of claims 1 to 14 when used to control the sound level of a coin-operated music system.

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